**NPT2020**

GaN General Purpose Transistor 48 V, 50 W
DC - 3.5 GHz

**Features**
- GaN on Si HEMT Depletion Mode Transistor
- Suitable for Linear and Saturated Applications
- Tunable from DC - 3.5 GHz
- 48 V Operation
- 13.5 dB Gain at 3.5 GHz
- 55 % Drain Efficiency at 3.5 GHz
- 100 % RF Tested
- Standard package with bolt down flange
- RoHS* Compliant and 260°C reflow compatible

**Description**
The NPT2020 GaN HEMT is a general purpose transistor optimized for DC - 3.5 GHz operation. This device supports CW, pulsed, and linear operation with output power levels to 50 W (47 dBm) in an industry standard surface mount package.

The NPT2020 is ideally suited for defense communications, land mobile radio, avionics, wireless infrastructure, ISM applications and VHF/UHF/L/S-band radar.

Built using the SIGANTIC® process - a proprietary GaN-on-Silicon technology.

**Functional Schematic**

**Ordering Information**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPT2020</td>
<td>Bulk Quantity</td>
</tr>
<tr>
<td>NPT2020-SMBPPR</td>
<td>Custom Sample Board¹</td>
</tr>
<tr>
<td>NPT2020-SMB2</td>
<td>1250-1850 MHz Sample Board</td>
</tr>
</tbody>
</table>

¹ When ordering, specify application requirements (frequency, linearity, etc.)

---


Visit [www.macom.com](http://www.macom.com) for additional data sheets and product information.
RF Electrical Specifications: \( T_A = 25 \, ^\circ C, \, V_{DS} = 48 \, V, \, I_{DO} = 350 \, mA \)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Conditions</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Signal Gain</td>
<td>( \text{CW, 3.5 GHz} )</td>
<td>( G_{SS} )</td>
<td>-</td>
<td>14.5</td>
<td>-</td>
<td>( \text{dB} )</td>
</tr>
<tr>
<td>Saturated Output Power</td>
<td>( \text{CW, 3.5 GHz} )</td>
<td>( P_{SAT} )</td>
<td>-</td>
<td>48</td>
<td>-</td>
<td>( \text{dBm} )</td>
</tr>
<tr>
<td>Drain Efficiency at Saturation</td>
<td>( \text{CW, 3.5 GHz} )</td>
<td>( \eta_{SAT} )</td>
<td>-</td>
<td>60</td>
<td>-</td>
<td>%</td>
</tr>
<tr>
<td>Power Gain</td>
<td>( 3.5 , \text{GHz}, , P_{OUT} = 50 , W )</td>
<td>( G_P )</td>
<td>12</td>
<td>13.5</td>
<td>-</td>
<td>( \text{dB} )</td>
</tr>
<tr>
<td>Drain Efficiency</td>
<td>( 3.5 , \text{GHz}, , P_{OUT} = 50 , W )</td>
<td>( \eta )</td>
<td>50</td>
<td>55</td>
<td>-</td>
<td>%</td>
</tr>
<tr>
<td>Ruggedness: Output Mismatch</td>
<td>All phase angles</td>
<td>( \psi )</td>
<td>VSWR = 10:1, No Device Damage</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

DC Electrical Characteristics: \( T_A = 25 \, ^\circ C \)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Conditions</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drain-Source Leakage Current</td>
<td>( V_{GS} = -8 , V, , V_{DS} = 160 , V )</td>
<td>( I_{DLK} )</td>
<td>-</td>
<td>-</td>
<td>14</td>
<td>mA</td>
</tr>
<tr>
<td>Gate-Source Leakage Current</td>
<td>( V_{GS} = -8 , V, , V_{DS} = 0 , V )</td>
<td>( I_{GLK} )</td>
<td>-</td>
<td>-</td>
<td>7</td>
<td>mA</td>
</tr>
<tr>
<td>Gate Threshold Voltage</td>
<td>( V_{DS} = 48 , V, , I_D = 14 , mA )</td>
<td>( V_T )</td>
<td>-2.5</td>
<td>-1.5</td>
<td>-0.5</td>
<td>V</td>
</tr>
<tr>
<td>Gate Quiescent Voltage</td>
<td>( V_{DS} = 48 , V, , I_D = 350 , mA )</td>
<td>( V_{GSQ} )</td>
<td>-2.1</td>
<td>-1.2</td>
<td>-0.3</td>
<td>V</td>
</tr>
<tr>
<td>On Resistance</td>
<td>( V_{DS} = 2 , V, , I_D = 105 , mA )</td>
<td>( R_{ON} )</td>
<td>-</td>
<td>0.34</td>
<td>-</td>
<td>( \Omega )</td>
</tr>
<tr>
<td>Saturated Drain Current</td>
<td>( V_{DS} = 7 , V, , \text{pulsed, pulse width 300} , \mu s )</td>
<td>( I_{D,\text{MAX}} )</td>
<td>-</td>
<td>8.2</td>
<td>-</td>
<td>A</td>
</tr>
</tbody>
</table>
### Absolute Maximum Ratings\(^{3,4,5}\)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Absolute Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drain Source Voltage, (V_{DS})</td>
<td>160 V</td>
</tr>
<tr>
<td>Gate Source Voltage, (V_{GS})</td>
<td>-10 to 3 V</td>
</tr>
<tr>
<td>Gate Current, (I_g)</td>
<td>28 mA</td>
</tr>
<tr>
<td>Junction Temperature, (T_J)</td>
<td>+200°C</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-40°C to +55°C</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>-65°C to +150°C</td>
</tr>
</tbody>
</table>

3. Exceeding any one or combination of these limits may cause permanent damage to this device.
4. MACOM does not recommend sustained operation near these survivability limits.
5. Operating at nominal conditions with \(T_J\) ≤ 200°C will ensure MTTF > 1 \times 10^6 hours.

### Thermal Characteristics\(^6\)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Conditions</th>
<th>Symbol</th>
<th>Typical</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Resistance</td>
<td>(V_{DS} = 48) V, (T_J = 200°C)</td>
<td>(R_{\text{JC}})</td>
<td>2.1</td>
<td>°C/W</td>
</tr>
</tbody>
</table>


### Handling Procedures

Please observe the following precautions to avoid damage:

#### Static Sensitivity

Gallium Nitride Circuits are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these HBM Class 1A devices.
Load-Pull Performance: $V_{DS} = 48\, \text{V}$, $I_{DQ} = 350\, \text{mA}$, $T_C = 25\, \text{°C}$
Reference Plane at Device Leads, CW Drain Efficiency and Output Power Tradeoff Impedance

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>$Z_S$ (Ω)</th>
<th>$Z_L$ (Ω)</th>
<th>$P_{SAT}$ (W)</th>
<th>$G_{SS}$ (dB)</th>
<th>Drain Efficiency at $P_{SAT}$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2700</td>
<td>1.6 - j7.2</td>
<td>2.9 + j2.3</td>
<td>65</td>
<td>16.2</td>
<td>58</td>
</tr>
<tr>
<td>3100</td>
<td>1.5 - j8.6</td>
<td>2.9 + j0.6</td>
<td>64</td>
<td>16.1</td>
<td>55</td>
</tr>
<tr>
<td>3500</td>
<td>1.9 - j10.7</td>
<td>2.9 - j0.7</td>
<td>62</td>
<td>15.7</td>
<td>53</td>
</tr>
</tbody>
</table>

**Impedance Reference**

**$Z_S$ and $Z_L$ vs. Frequency**

**Gain vs. Output Power**

**Drain Efficiency vs. Output Power**
Evaluation Board and Recommended Tuning Solution
3.5 GHz Narrowband Circuit

Description
Parts measured on evaluation board (20-mil thick RO4350). Matching is provided using a combination of lumped elements and transmission lines as shown in the simplified schematic above. Recommended tuning solution component placement, transmission lines, and details are shown on the next page.

Bias Sequencing

Turning the device ON
1. Set $V_{GS}$ to the pinch-off ($V_P$), typically -5 V.
2. Turn on $V_{DS}$ to nominal voltage (48 V).
3. Increase $V_{GS}$ until the $I_{DS}$ current is reached.
4. Apply RF power to desired level.

Turning the device OFF
1. Turn the RF power off.
2. Decrease $V_{GS}$ down to $V_P$.
3. Decrease $V_{DS}$ down to 0 V.
4. Turn off $V_{GS}$.
Evaluation Board and Recommended Tuning Solution
3.5 GHz Narrowband Circuit

Parts list

<table>
<thead>
<tr>
<th>Reference</th>
<th>Value</th>
<th>Tolerance</th>
<th>Manufacturer</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1, C5</td>
<td>1 µF</td>
<td>10%</td>
<td>AVX</td>
<td>1210C105KAT2A</td>
</tr>
<tr>
<td>C2, C6</td>
<td>0.1 µF</td>
<td>10%</td>
<td>Kemet</td>
<td>C1206C104K1RACTU</td>
</tr>
<tr>
<td>C3, C7</td>
<td>0.01 µF</td>
<td>10%</td>
<td>AVX</td>
<td>12061C103KAT2A</td>
</tr>
<tr>
<td>C4, C8</td>
<td>1000 pF</td>
<td>10%</td>
<td>Kemet</td>
<td>C0805C102K1RACTU</td>
</tr>
<tr>
<td>C9</td>
<td>10 pF</td>
<td>5%</td>
<td>ATC</td>
<td>ATC800B100JT500X</td>
</tr>
<tr>
<td>C10</td>
<td>12 pF</td>
<td>5%</td>
<td>ATC</td>
<td>ATC800B120JT500X</td>
</tr>
<tr>
<td>C11</td>
<td>4.7 pF</td>
<td>+/- 0.1 pF</td>
<td>ATC</td>
<td>ATC800B4R7BT500X</td>
</tr>
<tr>
<td>C12, C13</td>
<td>6.8 pF</td>
<td>+/- 0.1 pF</td>
<td>ATC</td>
<td>ATC800B6R8BT500X</td>
</tr>
<tr>
<td>C14</td>
<td>0.7 pF</td>
<td>+/- 0.1 pF</td>
<td>ATC</td>
<td>ATC800B0R7BT500X</td>
</tr>
<tr>
<td>C15</td>
<td>10 pF</td>
<td>5%</td>
<td>ATC</td>
<td>ATC800A100JT500X</td>
</tr>
<tr>
<td>C16</td>
<td>3.3 pF</td>
<td>+/- 0.1 pF</td>
<td>ATC</td>
<td>ATC800B3R3BT500X</td>
</tr>
<tr>
<td>C17</td>
<td>0.6 pF</td>
<td>+/- 0.1 pF</td>
<td>ATC</td>
<td>ATC800B0R6BT500X</td>
</tr>
<tr>
<td>R1</td>
<td>24.9 Ω</td>
<td>1%</td>
<td>Panasonic</td>
<td>ERJ-6GEY24R9V</td>
</tr>
<tr>
<td>R2</td>
<td>0 Ω</td>
<td>1%</td>
<td>Panasonic</td>
<td>ERJ-6ENF00R0V</td>
</tr>
<tr>
<td>PCB</td>
<td></td>
<td></td>
<td>Rogers RO4350, εr = 3.5, 20 mil</td>
<td></td>
</tr>
</tbody>
</table>
Typical Performance as Measured in the 3.5 GHz Evaluation Board:
CW, \( V_{DS} = 48 \text{ V} \), \( I_{DQ} = 350 \text{ mA} \) (unless noted)

**Gain vs. Output Power over Temperature**

**Drain Efficiency vs. Output Power over Temperature**

**Quiescent \( V_{GS} \) vs. Temperature**
Typical 2-Tone Performance as measured in the 3.5 GHz evaluation board:
1 MHz Tone Spacing, $V_{DS} = 48$ V, $I_{DQ} = 350$ mA, $T_C = 25$ °C (unless noted)

2-Tone IMD3 vs. Output Power vs. Quiescent Current

2-Tone IMD vs. Output Power

2-Tone Gain vs. Output Power vs. Quiescent Current

M/A-COM Technology Solutions Inc. (MACOM) and its affiliates reserve the right to make changes to the product(s) or information contained herein without notice. Visit www.macom.com for additional data sheets and product information.

For further information and support please visit: https://www.macom.com/support
Evaluation Board and Recommended Tuning Solution
1250-1850 MHz Broadband Circuit

Description
Parts measured on evaluation board (25-mil thick 6010LM). Matching is provided using a combination of lumped elements and transmission lines as shown in the simplified schematic above. Recommended tuning solution component placement, transmission lines, and details are shown on the next page.

Bias Sequencing

Turning the device ON
1. Set $V_{GS}$ to the pinch-off ($V_{P}$), typically -5 V.
2. Turn on $V_{DS}$ to nominal voltage (48 V).
3. Increase $V_{GS}$ until the $I_{DS}$ current is reached.
4. Apply RF power to desired level.

Turning the device OFF
1. Turn the RF power off.
2. Decrease $V_{GS}$ down to $V_{P}$.
3. Decrease $V_{DS}$ down to 0 V.
4. Turn off $V_{GS}$.
## Evaluation Board and Recommended Tuning Solution

1250-1850 MHz Broadband Circuit

### Parts list

<table>
<thead>
<tr>
<th>Reference</th>
<th>Value</th>
<th>Tolerance</th>
<th>Vendor</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>2.7 pF</td>
<td>+/- 0.1pF</td>
<td>ATC</td>
<td>ATC800B2R7BT500X</td>
</tr>
<tr>
<td>C2</td>
<td>27 pF</td>
<td>5%</td>
<td>ATC</td>
<td>ATC800B270JT500X</td>
</tr>
<tr>
<td>C3, C5, C6</td>
<td>47 pF</td>
<td>5%</td>
<td>ATC</td>
<td>ATC800B470JT500X</td>
</tr>
<tr>
<td>C4</td>
<td>10uF-16V</td>
<td>5%</td>
<td>Digikey</td>
<td>C2012X5R1C106M085AC</td>
</tr>
<tr>
<td>C7</td>
<td>1.0uF-100V</td>
<td>5%</td>
<td>Digikey</td>
<td>C12101C105KAT2A</td>
</tr>
<tr>
<td>C8</td>
<td>4.7uF</td>
<td>5%</td>
<td>Digikey</td>
<td>C5750X7R2A475K230KA</td>
</tr>
<tr>
<td>C9</td>
<td>100uF-63V</td>
<td>5%</td>
<td>Panasonic</td>
<td>ECE-V1JA101P</td>
</tr>
<tr>
<td>C10</td>
<td>3.9pF</td>
<td>+/- 0.1pF</td>
<td>ATC</td>
<td>ATC800B3R9BT500X</td>
</tr>
<tr>
<td>C11</td>
<td>39pF</td>
<td>5%</td>
<td>ATC</td>
<td>ATC800B390JT500X</td>
</tr>
<tr>
<td>C12</td>
<td>0.5pF</td>
<td>+/- 0.1pF</td>
<td>ATC</td>
<td>ATC800B0R5BT500X</td>
</tr>
<tr>
<td>C13</td>
<td>0.2pF</td>
<td>+/- 0.1pF</td>
<td>ATC</td>
<td>ATC800A0R2BT250X</td>
</tr>
<tr>
<td>L1</td>
<td>27nH</td>
<td>5%</td>
<td>Colcraft</td>
<td>0908SQ-27N</td>
</tr>
<tr>
<td>R1</td>
<td>110 Ohms</td>
<td>5%</td>
<td>Digikey</td>
<td>CR1206-JW-1100ELF</td>
</tr>
<tr>
<td>R2</td>
<td>0.33 Ohms</td>
<td>5%</td>
<td>Digikey</td>
<td>ERJ-6RQFR33V</td>
</tr>
<tr>
<td>PCB</td>
<td></td>
<td></td>
<td></td>
<td>Rogers 6010LM, ε, = 10.2, 25 mil</td>
</tr>
</tbody>
</table>

---

For further information and support please visit:
[https://www.macom.com/support](https://www.macom.com/support)

MA-COM Technology Solutions Inc. (MACOM) and its affiliates reserve the right to make changes to the product(s) or information contained herein without notice. Visit [www.macom.com](http://www.macom.com) for additional data sheets and product information.
Typical Performance as Measured in the 1250-1850 MHz Evaluation Board:
CW, VDS = 48 V, IDQ = 350 mA, TA = 25 °C (unless noted)

Gain & Drain Efficiency vs. Frequency (Max Power)

Gain & Drain Efficiency vs. Frequency (POUT = 50 W)

Gain & Drain Efficiency vs. POUT
AC360B-2 Metal-Ceramic Package†

† Meets JEDEC moisture sensitivity level 1 requirements. Plating is Ni / Au.
GaN General Purpose Transistor 48 V, 50 W
DC - 3.5 GHz

M/A-COM Technology Solutions Inc. All rights reserved.

Information in this document is provided in connection with M/A-COM Technology Solutions Inc ("MACOM") products. These materials are provided by MACOM as a service to its customers and may be used for informational purposes only. Except as provided in MACOM's Terms and Conditions of Sale for such products or in any separate agreement related to this document, MACOM assumes no liability whatsoever. MACOM assumes no responsibility for errors or omissions in these materials. MACOM may make changes to specifications and product descriptions at any time, without notice. MACOM makes no commitment to update the information and shall have no responsibility whatsoever for conflicts or incompatibilities arising from future changes to its specifications and product descriptions. No license, express or implied, by estoppels or otherwise, to any intellectual property rights is granted by this document.

THESE MATERIALS ARE PROVIDED "AS IS" WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESS OR IMPLIED, RELATING TO SALE AND/OR USE OF MACOM PRODUCTS INCLUDING LIABILITY OR WARRANTIES RELATING TO FITNESS FOR A PARTICULAR PURPOSE, CONSEQUENTIAL OR INCIDENTAL DAMAGES, MERCHANTABILITY, OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT. MACOM FURTHER DOES NOT WARRANT THE ACCURACY OR COMPLETENESS OF THE INFORMATION, TEXT, GRAPHICS OR OTHER ITEMS CONTAINED WITHIN THESE MATERIALS. MACOM SHALL NOT BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, INCLUDING WITHOUT LIMITATION, LOST REVENUES OR LOST PROFITS, WHICH MAY RESULT FROM THE USE OF THESE MATERIALS.

MACOM products are not intended for use in medical, lifesaving or life sustaining applications. MACOM customers using or selling MACOM products for use in such applications do so at their own risk and agree to fully indemnify MACOM for any damages resulting from such improper use or sale.